ESA 044-2_Kraft Foods_Granite City, IL
Steam ESA – Public Report - Final

Company	Kraft Foods Global, Inc	**ESA Dates**	April 10th to 12th
Plant	Granite City, Illinois	**ESA Type**	Steam
Product	Juice beverages	**ESA Specialist**	Tom Tucker, P.E.

Brief Narrative Summary Report for the Energy Savings Assessment:

Introduction:
The ESA and training activities were provided through the United States Department of Energy-Energy Savings Now initiative, which was begun to help the largest natural gas users in the United States identify ways to reduce energy use. On behalf of the Department of Energy, Tom Tucker of Kinergetics LLC conducted a steam system ESA at the Kraft Foods Global Inc facility in Granite City, Illinois from April 10th to April 12th, 2007.

The estimated annual energy cost savings for the projects evaluated is provided in **Table 1** above. If all projects listed are implemented would reduced the total energy used by 3%. Note that all efficiencies referenced below are based on stack losses and are not true fuel to steam efficiencies, which are typically 1 to 2-percent lower.

Steam System
Steam is provided by two (2) 500-hp boilers, one (1) 300-hp and one (1) 250-hp boiler. Both of the 500-hp boilers are equipped with economizers. At present the boilers are cycled so three (3) operate at any one time. The pressure set point is approximately 105-psig and the average steam rate was estimated at 17-kpph steam over 6,240 annual hours of operation. All of this steam is used for process operations. A small amount of water heating is provided by a direct fired water heater, although the annual gas use is expected to be relatively small.

Objective of ESA:
The primary objective of the ESA was to identify steam cost reduction opportunities and to have the primary ESA lead become comfortable with the concepts behind use of the DOE steam tools. Particular attention was given to the Steam System Assessment Tool (SSAT), although 3E Plus (v3.2) was also used to address insulation related projects.

Focus of Assessment:
SSAT was applied to model cost reduction opportunities identified during walk-throughs and group discussions. With respect to the assessment activities, particular attention was given to opportunities related to improved boiler loading and control, and identification of additional loads to place on the direct fired water heater already installed on-site.

Approach for ESA:
The ESA started with an introduction and a brief Power Point presentation introducing the different steam tools. The Steam System Scoping Tool (SSST) was completed prior to the assessment.

General Observations of Potential Opportunities:
Below are brief descriptions of each opportunity evaluated. Each opportunity has been rated based on the following definitions:

1. <u>Near term opportunities</u>: Include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
2. <u>Medium term opportunities</u>: Require purchase of additional equipment and/or changes in the system such as addition of recuperative air pre-heaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.

3. Long term opportunities: Require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.

1. Redistribute Boiler Steam Load to the 500-HP Boilers (Boiler #3 & Boiler #4) and Reduce Exhaust Oxygen (medium term)

The boiler operating strategy is to rotate the boilers to ensure relatively equal operating time. Generally, one 500-hp boiler is operated with either the 250-hp or 300-hp boiler acting as a "trim" boiler. During the assessment the 300-hp boiler was in operation for trim loads. Combustion efficiency testing was performed on the "old" 500-hp boiler and the 300-hp boiler with the results summarized in the table below.

Combustion Analysis Results

Boiler	Stack Temperature (°F)	Fire Position (%)	% Oxygen	Stack Loss (%)
300-hp	490	80 to 100	4.4	20.3
500-hp	280	90 to 100	6.6	15.5

The exhaust of the 500-hp was tested on the roof after the economizer. While the "new" 500-hp boiler was not tested, control readout indicates that the two boilers operate at similar efficiencies.

Since the 300-hp boiler operates approximately 50-percent of the time and the 250-hp boiler operates the other 50-percent, the efficiency of the steam system can be improved if that portion of the steam supplied by the smaller boilers is shifted to the more efficient 500-hp boilers and the smaller boilers are turned off. While the efficiency of the 250-hp boiler could not be tested since it was in wet storage, it was reported to be more efficient than the 300-hp boiler but less efficient than the 500-hp boilers. Thus, to facilitate cost savings calculations, it was assumed that the 250-hp boiler is 2-percent more efficient than the 300-hp boiler. This implies a stack temperature of approximately 410°F, which can be checked. The average efficiency between the 300-hp and 250-hp boilers is estimated at 81-percent.

Discussions with facility personnel indicate that the 300-hp boiler is approximately 75-percent loaded on average when is operating, which is approximately equivalent to a steam rate of 7,765-pph. Since the annual average steam rate was estimated at 17,000-pph, the "impact" boiler efficiency is:
(85% x (17,000 – 7,765) + 81% x 7,765) ÷ 17,000 = 83.2%

Shifting the steam supplied by the smaller boilers to the 500-hp boilers will improve the "impact" efficiency to that of the 500-hp boilers, or 85-percent, provides a reduction of 2% annual NG usage.

Once the shift has been made to the 500-hp boilers, tuning should be undertaken to reduce the exhaust oxygen from its present value of approximately 6.6-percent. A target of 3.5 to 4-percent is reasonable. Assuming that 4-percent can be obtained with the existing controls and burners, an additional efficiency gain of approximately 1-percent is possible.

2. Increase Boiler Efficiency: Recover Sensible Heat from Boiler Blow Down (medium term)

The current boiler steam system configuration does not include heat recovery from boiler blow down. The boiler feed water quality is reasonably good, allowing a blow down rate of approximately 5-percent (~900-pph). Blow down heat can be used to flash steam to the DA tank, with the remaining heat for make up water heating or simply using a properly applied shell and tube exchanger to recover *all* heat for makeup water heating. It appears to make more sense to simply use the blow down heat to preheat makeup water.

The economic value of recovering the blow down heat to preheat makeup water is approximately 1% savings per year. The simple return on blow down heat recovery systems is typically 6 months to 1 year due to higher natural gas prices in recent years. A single blow down recovery system can service two or more boilers although installed costs will be somewhat higher because of the additional piping. However, it is expected that the simple return will still be on the order of one year. This opportunity is recommended for detailed review and installation as appropriate.

3. Reduce Steam Demand – Minimize DA Venting (near term)

There are two vents on the DA tank that allow proper removal of dissolved oxygen and other gases from boiler feed water. Generally, the venting rate is approximately 1/10 of one percent of the design steam flow. The total steam system capacity for all four boilers is approximately 54,000-pph and the vent rate should be approximately 50-pph. While measurement was not possible, visual observation of the plume from one of the vents indicates a vent rate likely in the range of 200 to 300-pph. According to facility personnel, the excessive vent rate appears to be due to a worn orifice plate on a vent valve.

Assuming an average vent rate of 250-pph, the savings possible is 200-pph and the annual NG savings is approx 1%. Replacement of the orifice plate is recommended.

4. Improve Boiler Efficiency – Relocate Combustion Air Intake to the Indoors (medium term)

All of the boilers are configured to receive combustion air from outdoors due to the potential for drawing refrigerants or free chlorine into the combustion chamber. If acceptable alternatives such as local ventilation near the potential contaminant source can be used to prevent intake of refrigerants or chlorine, it may be permissible to relocate the combustion air intake to the indoors near the roof. This area is generally very hot in a boiler room and should allow the combustion air to be at a higher average temperature than ambient.

Based on BIN data (30 year average), the average annual temperature near Springfield, IL is approximately 52°F. This should be similar to the average annual temperature near Granite City. The temperature in the boiler room during the assessment was approximately 80°F. Reports indicate that the temperature is much higher in the summer months. Assuming that the average annual temperature in the boiler room is 90°F, the estimated efficiency gain from using indoor air is:

(90°F - 52°F) x 1% ÷ 40°F = 0.95%

Because the "new" 500-hp boiler is located in a separate room further away from potential contaminant sources, it is recommended that this boiler be considered first. The annual cost benefit is then based on the estimated average steam output from the "new" boiler at approximately 50-percent of the annual operating hours (3,120 hours). The efficiency gain equates to an annual NG savings is approx .3%.

If the combustion air for all operating boilers (or the two 500-hp boilers; Opportunity 1) can be ducted from indoors the annual cost savings is estimated at approximately $16,000. This is opportunity is recommended for further consideration.

5. Boiler Efficiency Improvement – Remove 150-HP boiler from Service (medium term)

A 150-hp satellite boiler is used to meet small steam loads on a separate steam header. Facility staff desire to shut down the boiler and pipe the steam header feed by the smaller boiler to the main header. Visual observation during the assessment indicated that the boiler was operating near minimum fire. Combustion analysis indicated an exhaust temperature of 330°F and an exhaust oxygen concentration of 8.2-percent. Based on boiler logs the blow down rate is sporadic so the blow down rate was assumed to be 5-percent, just as for the main steam system boilers.

Assuming that the boiler has a 3:1 turn down, the low fire steam rate is approximately 1,700-pph (50-hp). The design capacity fuel requirement is 6.2-MMBtu per hour. If the boiler is taken off line the cost reduction will result primarily from:

1. Reduced shell loss – Typical shell loss is 0.5 to 1-percent of boiler full load operation. Assuming a 1-percent loss based on full design load, the shell loss is approximately 62,000-Btu per hour.
2. Reduced blow down loss – At a blow down rate of 5-percent, the heat loss to blow down is approximately 35,000-Btu per hour.
3. Reduced stack loss (lower exhaust oxygen) – Reducing the exhaust oxygen from 8.2-percent to 4-percent is feasible if the 150-hp steam load is shifted to the main boilers. This will reduce stack loss by approximately 2-percent or 71,000-Btu per hour.

The total energy savings is the total of the individual savings above or 168,000-Btu/hr. This will provide an annual reduction of NG usage approx 1%.

6. Improve Boiler Efficiency – Reduce DA Tank Pressure (near term)
The DA tank operates at approximately 7-psig (232°F) using steam provided from the header. Lower pressures are often possible as long as the DA tank still provides effective removal of dissolved gasses. The advantage of lowering the DA pressure in this case is that lower temperature water will go to the economizers, increasing the temperature difference between the exhaust and incoming water and increasing the amount of exhaust heat removed. Since the DA tank is heated by steam, use of additional exhaust heat (waste) will directly offset boiler fuel. A lower DA tank pressure will also reduce the amount of steam vented.

The efficiency gain can be checked based on the temperature difference between the inlet and outlet economizer water temperature. A common guideline is that an 11°F rise in feed water temperature is approximately equivalent to a 1-percent increase in boiler efficiency. Assuming that the DA tank temperature is dropped to 220°F and that the exhaust heat raises it to 225°F, the efficiency gain is:
(225°F - 220°F) x 1% ÷ 11°F = 0.5%

The annual NG savings is approximately .5%. Assuming that the quality of the water leaving the DA is not reduced and no additional chemical treatment is required the simple return will be immediate.

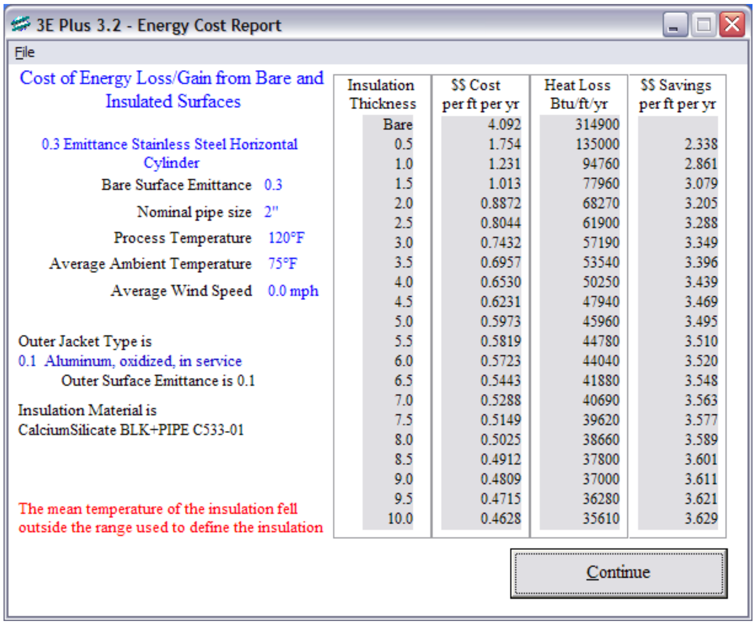
7. Reduce Steam Demand – Improve Loading on the Kemco Water Heater (near term)
A Kemco direct fired water heater was installed around 2001 that is used to heat water for wash down operations and for domestic hot water. However, the 12-MMBtu per hour unit appears to be operating at no where near its rated capacity. Since there is cold water being heated for production and CIP use, there is an opportunity to increase the use of this unit. One example cited is the use of city water from the Kemco directly on CIP skid #1. Since the water used by CIP skid #1 is already city water, discussions with staff indicate that there should be no quality related concerns from using the Kemco water directly. As this water is presently heated by steam, there should be a heating efficiency gain of approximately 15-percent *when water is being heated (see note below).*

Aside from potential energy cost reductions, the use of the Kemco to preheat CIP skid water will remove load from the steam system and should help reduce the likely hood that a third boiler is needed to meet peak steam demands.

The energy cost savings potential could not be accurately estimated since data on the volume of CIP water used could not be gathered for the assessment. However, to provide some guidance, it was assumed that each cycle requires 3,000 gallons of city water to be heated and that there are 15-cycles per week for 50 weeks per year. The total water volume is:
3,000 gal/cycle x 15-cycles/wk x 50 weeks/yr = 2,250,000 gallons/yr
The Kemco unit was heating water to approximately 120°F. The fuel required using the boiler to heat water to the same temperature is:
2,250,000 gallons x 8.34-lb/gallon x (120°F - 50°F) x (1-MMBtu/1,000,000 Btu) ÷ 81% = 1,622-MMBtu/yr

Under optimal operating conditions the Kemco unit will consume approximately:
2,250,000 gallons x 8.34-lb/gallon x (120°F - 50°F) (1-MMBtu/1,000,000 Btu) ÷ 96% = 1,368-MMBtu/yr

8. Improve Steam Line Insulation (near term)
With natural gas prices as high as $10 per million Btu, any pipe about 2-inches in diameter or greater with a surface temperature equal to or greater than 120°F should be insulated. The screen shot below is a 3EPlus model run that shows the cost savings possible when insulating 2-inch pipe with a surface temperature of 120°F. If a reasonably large quantity of insulation is required, the installed cost of insulation for this pipe is estimated at $6 to $10 per lineal foot. The simple return would be in the range of two to three years.



3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.3 Emittance Stainless Steel Horizontal Cylinder

Bare Surface Emittance 0.3

Nominal pipe size 2"

Process Temperature 120°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

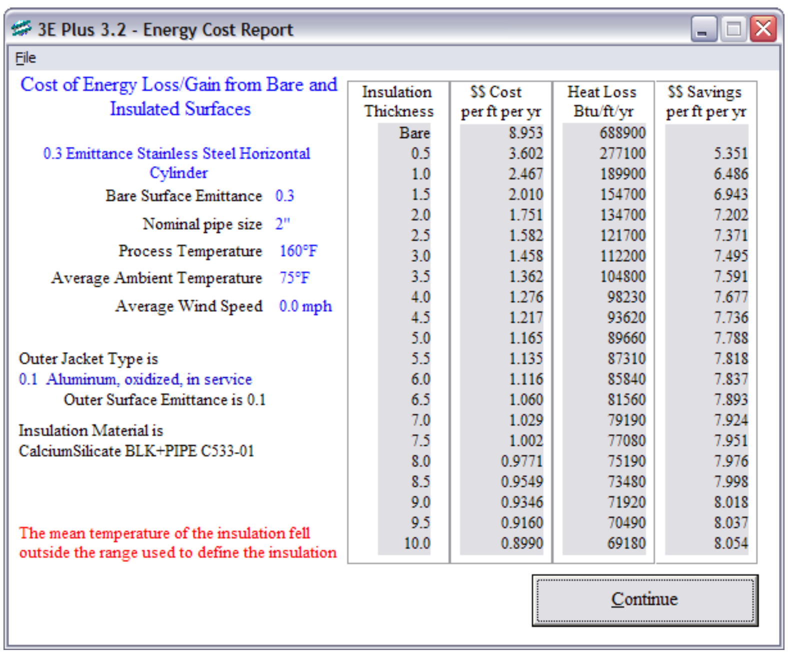
Insulation Material is
CalciumSilicate BLK+PIPE C533-01

The mean temperature of the insulation fell outside the range used to define the insulation

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	4.092	314900	
0.5	1.754	135000	2.338
1.0	1.231	94760	2.861
1.5	1.013	77960	3.079
2.0	0.8872	68270	3.205
2.5	0.8044	61900	3.288
3.0	0.7432	57190	3.349
3.5	0.6957	53540	3.396
4.0	0.6530	50250	3.439
4.5	0.6231	47940	3.469
5.0	0.5973	45960	3.495
5.5	0.5819	44780	3.510
6.0	0.5723	44040	3.520
6.5	0.5443	41880	3.548
7.0	0.5288	40690	3.563
7.5	0.5149	39620	3.577
8.0	0.5025	38660	3.589
8.5	0.4912	37800	3.601
9.0	0.4809	37000	3.611
9.5	0.4715	36280	3.621
10.0	0.4628	35610	3.629

Continue

The screen shot below shows the value of insulating 2-inch diameter condensate pipe at 160°F. The assumed cost for the insulation, again assuming that there is a reasonable amount of insulation to be installed, is approximately $10 per lineal foot. At this price the simple return is approximately 1.5 years.



3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.3 Emittance Stainless Steel Horizontal Cylinder

Bare Surface Emittance 0.3

Nominal pipe size 2"

Process Temperature 160°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

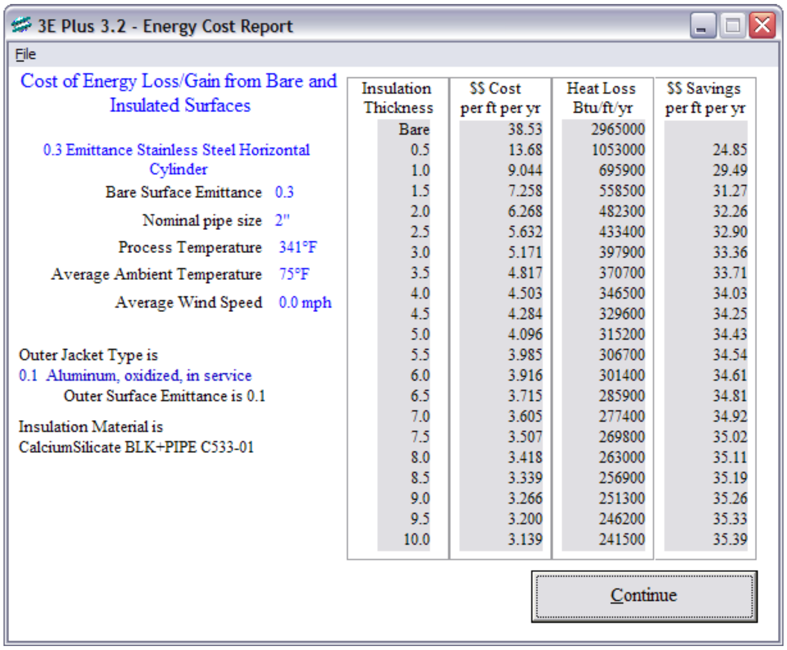
Insulation Material is
CalciumSilicate BLK+PIPE C533-01

The mean temperature of the insulation fell outside the range used to define the insulation

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	8.953	688900	
0.5	3.602	277100	5.351
1.0	2.467	189900	6.486
1.5	2.010	154700	6.943
2.0	1.751	134700	7.202
2.5	1.582	121700	7.371
3.0	1.458	112200	7.495
3.5	1.362	104800	7.591
4.0	1.276	98230	7.677
4.5	1.217	93620	7.736
5.0	1.165	89660	7.788
5.5	1.135	87310	7.818
6.0	1.116	85840	7.837
6.5	1.060	81560	7.893
7.0	1.029	79190	7.924
7.5	1.002	77080	7.951
8.0	0.9771	75190	7.976
8.5	0.9549	73480	7.998
9.0	0.9346	71920	8.018
9.5	0.9160	70490	8.037
10.0	0.8990	69180	8.054

Continue

The screen shot below shows the value of insulating 2-inch diameter *steam* pipe. The cost for the insulation, again assuming that there is a reasonable amount of insulation to be installed, is approximately $10 per lineal foot. At this price the simple return is approximately 6 months.



3E Plus 3.2 - Energy Cost Report

File

Cost of Energy Loss/Gain from Bare and Insulated Surfaces

0.3 Emittance Stainless Steel Horizontal Cylinder

Bare Surface Emittance 0.3

Nominal pipe size 2"

Process Temperature 341°F

Average Ambient Temperature 75°F

Average Wind Speed 0.0 mph

Outer Jacket Type is
0.1 Aluminum, oxidized, in service
Outer Surface Emittance is 0.1

Insulation Material is
CalciumSilicate BLK+PIPE C533-01

Insulation Thickness	$$ Cost per ft per yr	Heat Loss Btu/ft/yr	$$ Savings per ft per yr
Bare	38.53	2965000	
0.5	13.68	1053000	24.85
1.0	9.044	695900	29.49
1.5	7.258	558500	31.27
2.0	6.268	482300	32.26
2.5	5.632	433400	32.90
3.0	5.171	397900	33.36
3.5	4.817	370700	33.71
4.0	4.503	346500	34.03
4.5	4.284	329600	34.25
5.0	4.096	315200	34.43
5.5	3.985	306700	34.54
6.0	3.916	301400	34.61
6.5	3.715	285900	34.81
7.0	3.605	277400	34.92
7.5	3.507	269800	35.02
8.0	3.418	263000	35.11
8.5	3.339	256900	35.19
9.0	3.266	251300	35.26
9.5	3.200	246200	35.33
10.0	3.139	241500	35.39

Continue

In addition to steam, condensate and water lines, valves and regulators such as the steam pipe/valves off of the boilers, are also areas worthy of insulation. Steam valves and regulators can be insulated with "removable" insulation to allow maintenance when necessary. Removable insulation is more expensive than standard pipe insulation but can be cost effective. A few suppliers are provided below for convenience but no endorsement of any particular supplier is implied.

- B&B insulation: 920.733.6086
- Advance Thermal Corporation: 630.595.5150
- Coverflex Manufacturing: 713.378.0966

Given natural gas prices, it is recommended that all condensate return and steam supply piping be insulated. The only exception is on the cooling leg of thermostatic steam traps, since these traps rely on condensate subcooling to function properly. Generally, insulation projects can be considered a "just do it" type projects, with no need to estimate savings since the return will be on the order of one year or less.

9. Repair Steam Leaks (near term)

There were a number of steam leaks noted during the assessment, a few being:

- On the hot water set East – steam / condensate leak
- Common base area hot set
- Failing gasket on a shell and tube exchanger
- Steam leak on a valve
- Failed hand valve

10. Steam Trap Maintenance Program (near term)

Steam traps are recognized as important to maintain due to the potential to increase flash and/or live steam loss to the atmosphere through vented vessels. Steam traps that fail open and go undetected increase parasitic boiler steam loads, boiler operation costs, make-up water use and water treatment chemical costs. Based on the information available, the steam traps have likely not been tested in over two years and when they have been tested, there is question as to the effectiveness of the "repair or replacement" component of the trap program.

Steam savings is sometimes difficult to determine with certainty. While the economic benefit from steam trap repair and replacement can be significant, it is not always but depends on how much energy actually leaves the "system."

Nevertheless, an effective trap program is important and should be followed to minimize waste and protect worker safety. Use of outside vendors is often an effective means to accomplish this given time constraints on facility personnel. The simple return for steam trap maintenance is typically on the order of one to two years.

Until the trap failure rate is under control it is recommended that inspection and repair or replacement be performed at least twice per year. The frequency may be decreased as the number of identified failures stabilizes.

Note: A steam trap assessment is planned for the near future.

Management Support and Comments:
Generally, the initial feedback from the ESA group was favorable. Overall the group was very engaged and interested in applying the models to help screen cost reduction opportunities.

DOE Contact at Plant/Company: (who DOE would contact for follow-up regarding progress in implementing ESA results…)

Plant Contact: Allen Friedman
Company Contact: Randy Short